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(54) **High performance shaped charge**

(57) Shaped charge which can have a symmetry of revolution about an axis, has a priming system constituted by a punctiform initiating source 5 producing a detonation wave in a donor explosive block 6 and a cavity 8 positioned between the donor explosive and the receiver explosive, said cavity being shaped in such a way that the detonation wave 13 in the receiver explosive and then in the charging explosive 4 can be planar and perpendicular to the axis of the charge. The cavity may be evacuated or may contain compressed gas or polystyrene foam. A liner 11 may be provided.

Application to the piercing of high strength steel sheets.

FIG.1

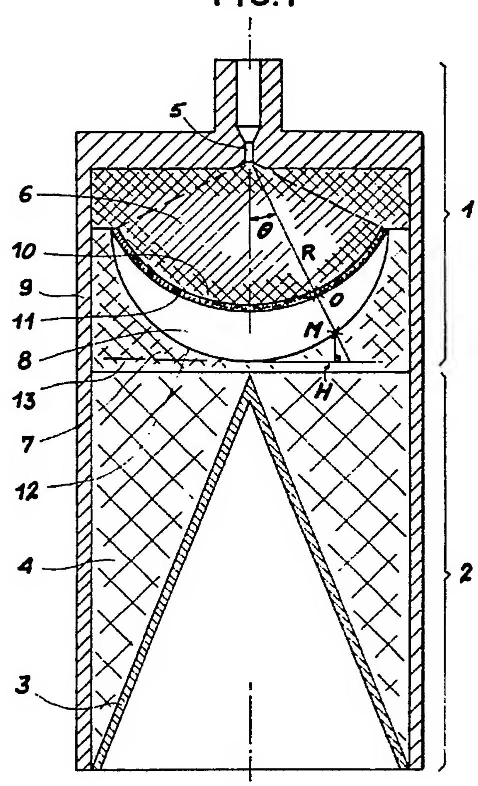

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FIG.1

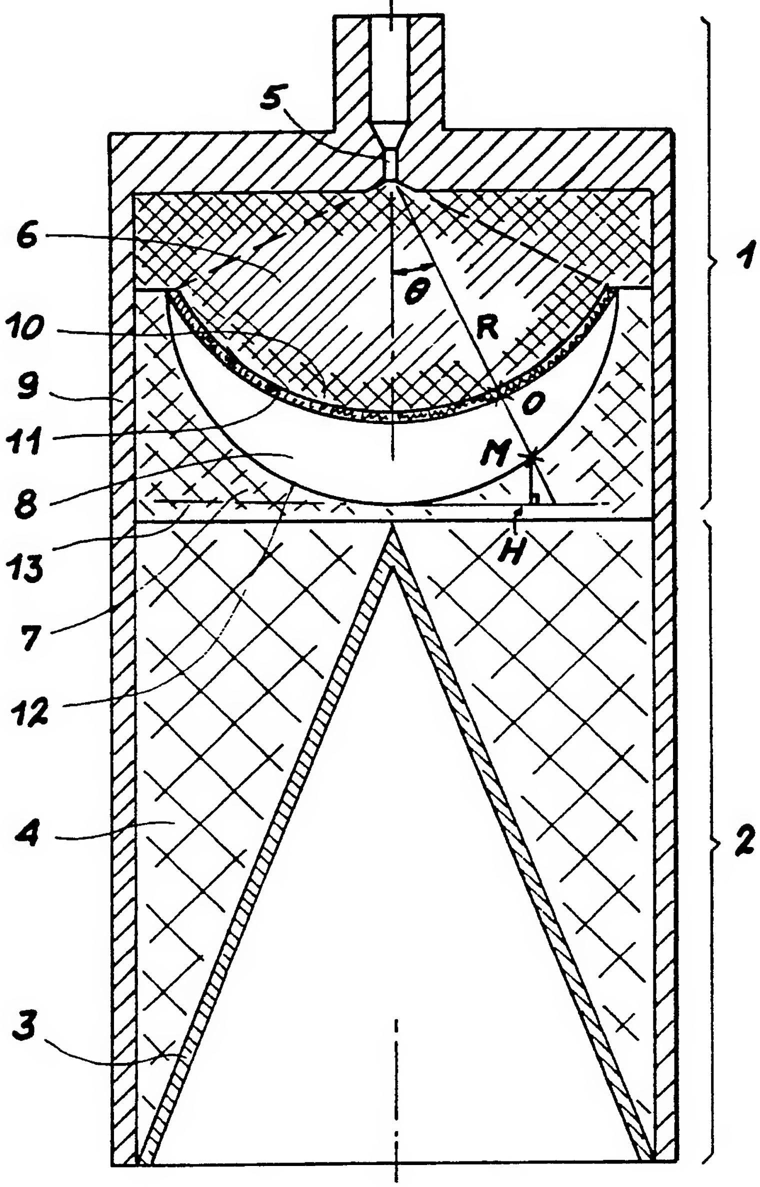


FIG. 2

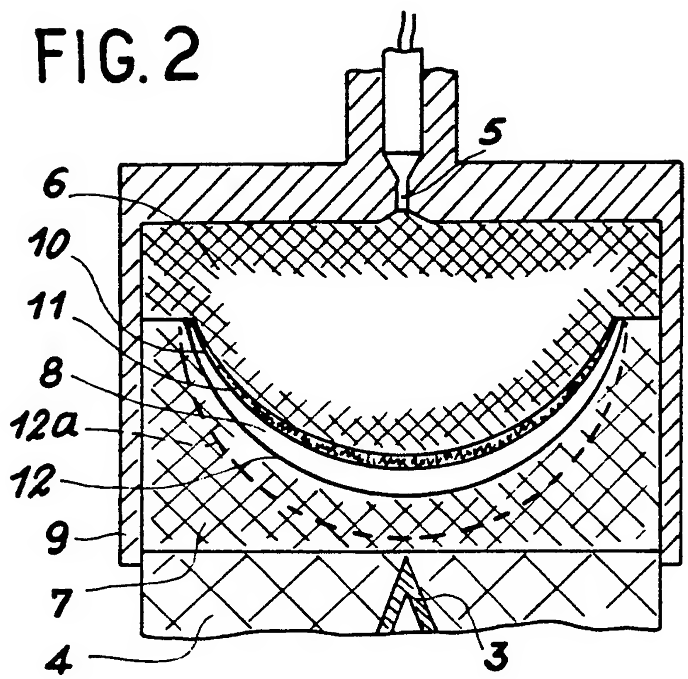


FIG. 3

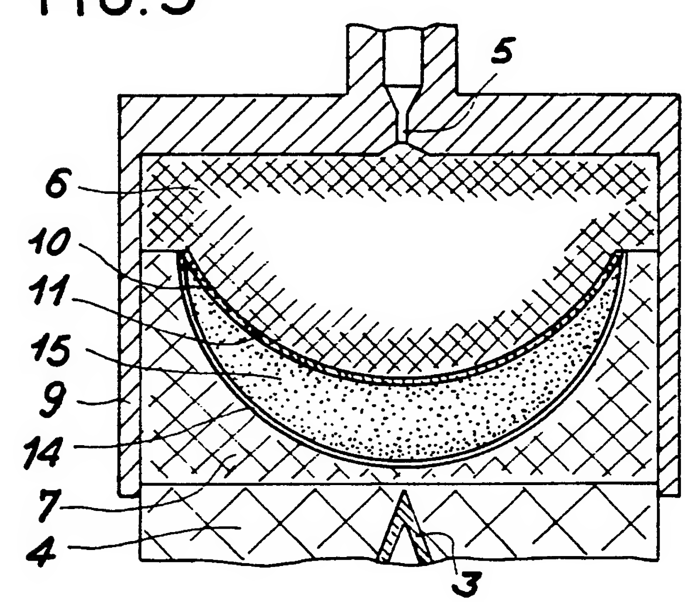
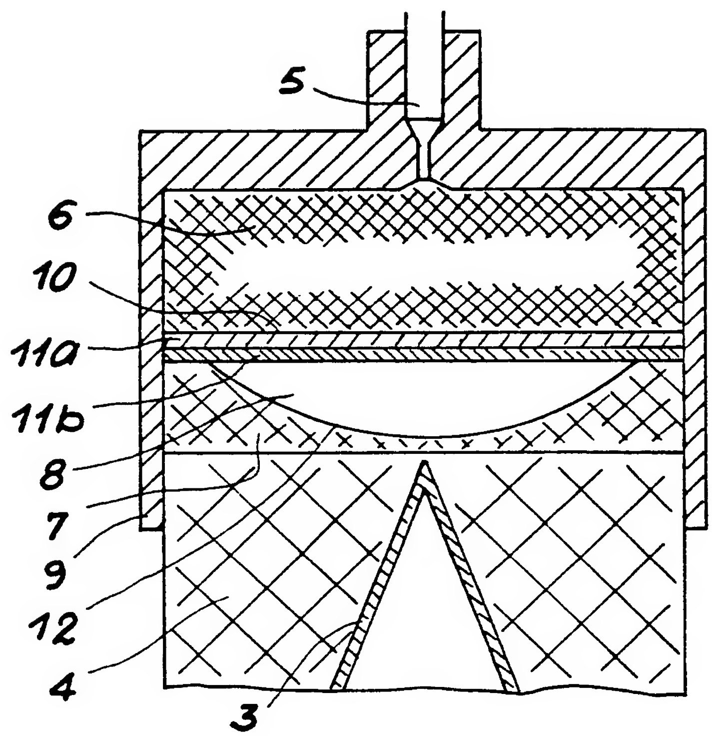


FIG. 4



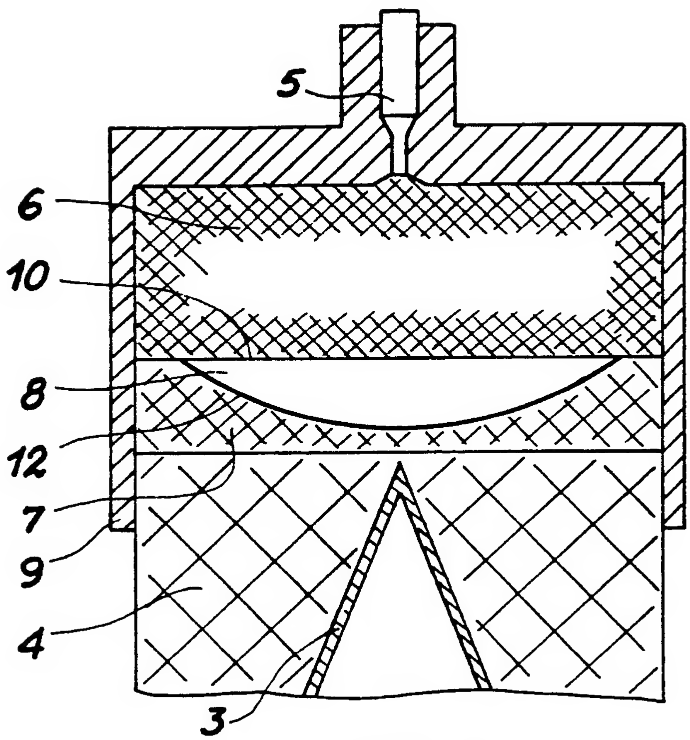
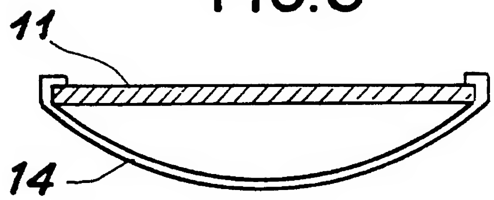


FIG.5

FIG.6



SHAPED CHARGE

BACKGROUND OF THE INVENTION

The present invention relates to a new type of shaped charge and particularly a hollow charge having a revolution shape covering, which can be conical or possibly dihedral and which is moved by a charging explosive initiated by a priming explosive block.

Modern developments in this technical field are seeking a significant increase in the piercing or perforating power of the shaped charges and particularly hollow charges. This research has led to consideration being given to the use of high performance covering geometries (closed angles, reduced thickness), but which are correlatively relatively sensitive to technical defects and particularly priming detonation wave distortions.

The hitherto produced shaped charges are equipped with priming systems having spherical waves (punctiform priming) or toroidal waves (annular priming). Experimental results have revealed that passing from punctiform priming to annular priming leads to an approximately 15% increase in the depths by which high-strength steel is pierced. However, a serious disadvantage of this priming procedure is due to a lack of performance reproducibility. This is on the one hand due to the naturally unstable character of convergent detonation wave systems and on the other hand to the considerable sensitivity of the covering projection mechanism limiting the hollow charge to

the symmetry defects of the detonation wave when it simultaneously attacks the said covering.

Another problem generally encountered with this type of priming results from the need for the detonation wave to acquire a maximum energy level. This makes it necessary for the detonation wave to pass along an adequate "detonation path" between the initiation point and the covering. Generally this constraint seriously penalizes the weight and overall dimensions balances of the device.

SUMMARY OF THE INVENTION

The present invention aims at obviating these disadvantages by means of an improved shaped charge making it possible to simultaneously achieve the following advances:

- use of the highest performance covering geometries (particularly closed angles and reduced thicknesses);
- use of extremely high energy explosives, which are sometimes difficult to prime by conventional methods, particularly in connection with TNT binder explosives;
- technical ease of manufacture and fitting the charges, because the plane wave is relatively insensitive to the coaxiality problems, of the priming block and the hollow charge block;
- reduced weight and overall dimensions, because the wave produced by the charging explosive has an energy profile which can be immediately used for the projection of the hollow charge cone, so that the latter

can be located in the immediate vicinity of the priming system;

- increase in the energy transferred to the covering by the effect of the axial confinemenet produced, i.e. the rearward expansion of the detonation wave is limited.

The shaped charge according to the invention has a priming system comprising:

- an initiating source producing a detonation wave in the priming explosive block, which is constituted by a donor explosive and a receiver explosive;
- a cavity positioned between the donor explosive and the receiver explosive and shaped such that the surface limiting the cavity at the donor explosive cooperates with the shape of the surface limiting the cavity at the receiver explosive in such a way that the detonation wave in the receiver explosive and then in the charging explosive is planar and perpendicular to the axis of revolution or to the plane of symmetry of the covering.

According to another feature, the surface of the cavity at the donor explosive is planar or concave (spherical, ellipsoidal, paraboloid, hyperboloid, etc.).

The surface limiting the cavity at the donor explosive can be covered with a projection covering which, during priming, is to be projected on to the surface limiting the cavity on the side of the receiver explosive.

According to another feature of the invention,

the projection covering can be metallic, bimetallic, composite, organic or organometallic. The thickness of the covering can be constant or variable (in this case decreasing from the axis towards the periphery).

According to another feature, the cavity can be constituted by a vacuum, a gas under a low pressure (equal to or below 1 bar), e.g. nitrogen or by a compressible lightweight material such as a foam.

According to other features:

- the surface limiting the cavity at the receiver explosive can be covered with a metallic and/or organic coating;
- the projection covering and the coating on the surface limiting the cavity at the receiver explosive constitute a tight capsule;
- the apex of the covering of the shaped charge is positioned in the vicinity of the cavity;
- the priming system only or the complete charge can be confined in a rigid envelope.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in greater detail hereinafter relative to non-limitative embodiments and with reference to the attached drawings, wherein show:

Fig. 1 a longitudinal section through a shaped charge according to the invention and its priming device.

Figs. 2 to 5 variants of the priming system.

Fig. 6 the tight capsule formed by the projection covering and the coating limiting the cavity on the side of the receiver explosive.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a first embodiment of a priming system 1 associated with a hollow charge 2 which, in conventional manner, comprises a conical covering 3 and the so-called "charging explosive".

The priming system comprises a punctiform initiating source, a first explosive called the "donor explosive", a second explosive called the "receiver explosive", and a cavity 8 between said donor and receiver explosives, the complete entity being included in an envelope 9. The latter may only surround the priming system 1 or may completely envelop the charge. When it is present, said envelope increases the efficiency of the assembly bringing about a confinement of the detonation products, i.e. by limiting the expansion of the detonation wave.

In the embodiment shown in Fig. 1, the cavity 8, viewed in section, is in the shape of a crescent. Surface 10 of donor explosive 6 is shaped like a sphere centred on the priming point of the charge. Surface 10 is covered with a metallic, ductile projection covering 11 which, in the particular case described here, is made from copper. The shape of the surface 12 limiting the cavity on the side of the receiver explosive 7 is defined in such a way that the detonation wave, after the projection covering 11 has passed

through the entire cavity 8, is planar in the vicinity of the apex of covering 3.

This surface is determined in the following way. On considering a radius R of the spherical surface 10 forming an angle θ with the axis of the charge, surface 12 must be such that, on wishing to obtain a plane wave as from the plane 13 perpendicular to the axis of the charge and tangential to surface 12, it is necessary to prove the relations:

$$(R + OM) \cos \theta + MH = a$$

$$\frac{R}{D_1} + \frac{OM}{V_0} + \frac{MH}{D_2} = \tau$$

- O and M being the intersections of radius R with the respective surfaces 10 and 12,
- H being the projection of M on plane 13,
- D_1 and D_2 being the respective detonation velocities of the donor explosive and the receiver explosive;
- a being the distance between the punctiform initiating source and plane 13,
- τ being the time taken by the detonation wave from the punctiform source to the plane 13, and
- V_0 being the projection speed of covering 11.

Surface 12 is then given by the following table:

θ (d°)	$\frac{OM}{R}$
0	0.333
10	0.327
20	0.307
30	0.276
40	0.237
50	0.191
60	0.143
70	0.093
80	0.045
90	0

The variant represented in Fig. 2 shows a priming system according to the invention, for which the projection covering 11 has a variable thickness. Thus, the thickness is greater in the area located in the axis of the charge and decreases towards the edges of the cavity. In this particular case, the covering mass or weight per surface unit projected on the opposite face of the cavity during priming decreases in the same way. Thus, the speed of the covering in an axial region is substantially less than that in the peripheral areas. This more particularly leads to a reduction in the distance OM, i.e. the width of the cavity 8 in the area adjacent to the axis of the charge, which makes it possible to obtain a priming system with reduced overall dimensions.

The broken line 12a in Fig. 2 indicates what would be the location of surface 12 limiting the cavity 8 on the side of the receiver explosive 7,

on choosing a projection covering 11 with a constant thickness.

Fig. 3 shows another embodiment, in which the projection covering 11 is made from copper, whilst the receiver explosive 7 is covered with a metallic coating 15, e.g. of steel, which has the function of reinforcing the mechanical strength of the receiver explosive.

Moreover, in this case, cavity 8 is filled with a honeycomb material 15, whereby the latter can be a foam such as expanded polystyrene, which is consequently highly compressed at the time of priming.

Fig. 4 shows another possible embodiment of cavity 8. The surface 10 of the donor explosive is planar and is covered with a composite projection covering 11, constituted by two plates 11a and 11b. Plate 11a can be made from plexiglass or aluminium and plate 11b from copper. The object of this composite structure is to prevent flaking off of plate 11b including the projection thereof, because a possible flaking off would be prejudicial to the repriming conditions for receiver explosive 7.

Fig. 5 shows a priming system, in which the surfaces 10 and 12 are not covered by a film, which simplifies the manufacture of the device.

Finally, Fig. 6 shows a capsule which can be tight and which is constituted by the projection covering 11, and the metallic film 14 covering surface 12.

Other variants can be envisaged without passing beyond the scope of the invention. Thus,

surfaces 10 can be ellipsoidal, paraboloid, hyperboloid or more generally have a shape such that the surface is expansible, i.e. at the time of the explosion the tangential deformation stresses of the plate or projection covering are tensile stresses. Moreover, the cavities can contain a gas, which can be inert e.g. nitrogen. A vacuum can also be produced, particularly in the case of the capsule-like cavity of Fig. 6. The projection covering 11, as well as the metallic film 14 can be in intimate contact with the explosives, but can also be arranged in such a way that there is a space between these coverings and the adjacent explosive mass, whereby said space can be under vacuum or can contain air or a particular gas.

WHAT IS CLAIMED IS:

1. A shaped charge, particularly a hollow charge, having a covering with a revolution shape and which can be conical or dihedral, which is moved by a charging explosive initiated by a priming system incorporating a donor explosive and a receiver explosive, wherein the said shaped charge comprises:

- an initiating source producing a detonation wave in the donor explosive;
- a cavity positioned between the donor explosive and the receiver explosive and shaped in such a way that the surface limiting the cavity of the donor explosive cooperates with the shape of the surface limiting the cavity at the receiver explosive, so that the detonation wave in the receiver explosive and then in the charging explosive is planar and perpendicular to the axis of revolution, or to the plane of symmetry of the covering.

2. A shaped charge according to claim 1, wherein the surface of the cavity at the donor explosive is planar.

3. A shaped charge according to claim 1, wherein the surface limiting the cavity on the side of the donor explosive is concave.

4. A shaped charge according to claim 3, wherein

the surface limiting the cavity at the donor explosive is spherical, ellipsoidal, paraboloid or hyperboloid.

5. A shaped charge according to claim 1, wherein the surface limiting the cavity of the donor explosive is covered with a projection covering which, during the explosion, is projected on to the surface limiting the cavity on the side of the receiver explosive.

6. A shaped charge according to claim 1, wherein the projection covering is metallic.

7. A shaped charge according to claim 1, wherein the projection covering is a composite material.

8. A shaped charge according to claim 7, wherein the material constituting the projection covering is a multimetallic, organic or organometallic material.

9. A shaped charge according to claim 5, wherein the projection covering is symmetrical relative to the axis of revolution and has a thickness decreasing from the axis towards the periphery.

10. A shaped charge according to claim 1, wherein the cavity contains a low pressure gas.

11. A shaped charge according to claim 1, wherein the cavity contains a compressible lightweight material, such as a foam.

12. A shaped charge according to claim 1, wherein the cavity is limited at the receiver explosive by a metallic and/or organic coating.

13. A shaped charge according to claim 12, wherein the projection covering and the coating limiting the cavity at the receiver explosive constitute a tight capsule.

14. A shaped charge according to claim 1, wherein there is a layer of air or gas between the donor explosive and the projection covering.

15. A shaped charge according to claim 1, wherein the apex of the covering of the shaped charge is located in the vicinity of the cavity.

16. A shaped charge according to claim 1, wherein it is confined in a rigid envelope.

17. A shaped charge substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Amendments to the claims have been filed as follows

1. A shaped charge comprising a charging explosive having an axis and a lining arranged symmetrically with respect to that axis, and a priming system for the charging explosive comprising a donor explosive and a receiver explosive, the receiver explosive being in planar face to face abutment with the charging explosive, wherein said shaped charge comprises:

- an initiating source producing a detonation wave in the donor explosive;
- a cavity positioned between the donor explosive and the receiver explosive, said cavity being limited by a first surface on the donor explosive and a second surface on the receiver explosive, said cavity being

shaped in such a way that the first surface cooperates with the shape of the second surface so that the detonation wave, having been produced in the donor explosive is passed through the cavity to the receiver explosive so that, in the receiver explosive, and then in the abutting charging explosive, it is planar and perpendicular to the axis of symmetry of the lining.

2. A shaped charge according to claim 1, which is a hollow charge.

3. A shaped charge according to claim 2, wherein the lining has a surface of revolution.

4. A shaped charge according to claim 3, wherein the lining is conical.

5. A shaped charge according to claim 2, wherein the lining has a dihedral shape.

6. A shaped charge according to any one of claims 1 to 5, wherein the first surface is planar.

7. A shaped charge according to any one of claims 1 to 5, wherein the first surface is convex.

8. A shaped charge according to claim 7, wherein the first surface is part spherical, ellipsoidal, paraboloid or hyperboloid.

9. A shaped charge according to any one of claims 1 to 5, wherein the first surface is coated with a projection coating which, during the explosion, is projected on to the second surface.

10. A shaped charge according to any one of claims 1 to 5, wherein the projection coating is metallic.

11. A shaped charge according to any one of claims 1 to 5, wherein the projection coating is a composite material.

12. A shaped charge according to claim 11, wherein the material constituting the projection coating is a multi-metallic, organic or organometallic material.

13. A shaped charge according to claim 9 when appended to claim 3, wherein the projection coating is symmetrical relative to the axis of revolution and has a thickness decreasing from the axis towards the periphery.

14. A shaped charge according to any one of claims 1 to 5, wherein the cavity contains a low pressure gas.

15. A shaped charge according to any one of claims 1 to 5, wherein the cavity contains a compressible lightweight material, such as a foam.

16. A shaped charge according to any one of claims 1 to 5, wherein the cavity is limited at the receiver explosive by a metallic and/or organic coating.

17. A shaped charge according to claim 16, wherein the projection coating and the coating limiting the cavity at the receiver explosive constitute a tight capsule.

18. A shaped charge according to any one of claims 1 to 5, wherein there is a layer of air or gas between the

donor explosive and the projection coating.

19. A shaped charge according to claim 4, wherein the apex of the lining of the shaped charge is located in the vicinity of the cavity.

20. A shaped charge according to any one of claims 1 to 5, wherein at least the priming system is confined in a rigid envelope.

21. A shaped charge substantially as hereinbefore described with reference to the accompanying drawings and as illustrated in Figure 1 of those drawings or modified as illustrated in any one of Figures 2 to 6 of those drawings.

PATENTS ACT 1977
EXAMINER'S REPORT TO THE COMPTROLLER
UNDER SECTION 17(5)
(The Search Report)

-17-

Application No.

8420375

FIELD OF SL..RCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification F3A

(Collections other than UK, EP & PCT:)

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
X	GB - 1596832 (RHEINMETALL)	Claim 1, at least
X	GB - 1152173 (SCHLUMBERGER)	"
X	GB - 714747 (LUVO)	"
X	GB - 677824 (SCHLUMBERGER) see particularly Fig 15 and associated description	"
X	GB - 610106 (M.B.A.) see particularly Fig 4 and associated description	"
X	US - 4004515 (NAVY)	"

CATEGORY OF CITED DOCUMENTS

- X relevant if taken alone
- Y relevant if combined with another cited document
- P document published on or after the declared priority date but before the filing date of the present application
- E patent document published on or after, but with priority date earlier than, the filing date of the present application

Search examiner J S Booth

Date of search 14 January 1985

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